UNIVERSITI PUTRA MALAYSIA

APPLICATION OF ELECTRICAL RESISTIVITY METHOD IN QUANTITATIVE ASSESSMENT OF GROUNDWATER RESERVE OF UNCONFINED AQUIFER

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FSAS 2000 12

APPLICATION OF ELECTRICAL RESISTIVITY METHOD IN QUANTITATIVE ASSESSMENT OF GROUNDWATER RESERVE OF UNCONFINED AQUIFER

BY

HAGO ALI HAGO

Thesis Submitted in Fulfilment of Requirements for the Degree of Master of Science in the Faculty of Science and Environmental Studies Universiti Putra Malaysia

January 2000

DEDICATED TO

The soul of my beloved brother **Mohammed El Fadl El Amin**

in his falseless abode. Who was my true mentor in the

wisdom of his words and in the strength

of his protection. May Allah

accept him as a true

shahid.

Abstract of thesis presented to the senate of Universiti Putra Malaysia in fulfilment of the requirements for the degree of Master of Science.

APPLICATION OF ELECTRICAL RESISTIVITY METHOD IN QUANTITATIVE ASSESSMENT OF GROUNDWATER RESERVE OF UNCONFINED AQUIFER

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Chairman: Associate Professor Shaharin Ibrahim, Ph.D.

Faculty: Science and Environmental Studies

The thesis describes the application of the electrical resistivity method in groundwater exploration carried out at Bukit Jalil-Serdang area, Selangor Darul Ehsan, Malaysia. Electrical Resistivity Imaging surveys have been conducted in order to locate, delineate subsurface water resources and estimate its reserve. A Wenner electrode configuration was employed. The field survey was conducted along thirteen profiles providing continuous coverage. Color-modulated sections of resistivity versus depth were plotted for all lines, giving an approximate image of the subsurface structure. The field survey was accompanied by a laboratory work. Resistivity of rock and soil samples taken from the field was measured and the resistivity formation factors were obtained. The porosity of the same sample was

calculated. A relationship between the porosity and the formation factor has been established. The laboratory established relationship was applied to the data obtained in the field to calculate the porosity values of the formation present within the investigated area. The porosity values were contoured and plotted. Depth to the bedrock for each line was obtained. A 2-dimensional and 3-dimensional representation of the subsurface topography of the area was prepared using a commercial computer software. The use of the software also enabled the computation of groundwater reserve within the investigated area.

The results showed that the layer associated with the aquifer has resistivities between 20 Ω.m and 150 Ω.m and is located at a depth varying from 5 to 20m. The layer has porosity between 18% and 35%. The results obtained from the electrical resistivity profiles indicate that the aquifer occupies a surface area of about 15977900 m^2 and has a mean depth of 13m, with net volume of 204610000 m^3. The average aquifer porosity is 30%. Therefore, a usable capacity of about 61,383,000 ± 6,752,130 m^3 can be inferred.

Abstrak tesis ini dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk mendapatkan Ijazah Master Sains.

PENGGUNAAN KAEDAH KERINTANGAN ELEKTRIK DALAM PENINJAUAN SECARA KUANTITATIF SIMPANAN AIR BAWAH TANAH UNTUK AKUIFER TERBUKA

Oleh

HAGO ALI HAGO

Januari 2000

Pengerusi: Profesor Madya Shaharin Ibrahim, Ph.D.

Fakulti: Sains dan Pengajian Alam Sekitar

Kajian ini menerangkan satu contoh penggunaan kaedah kerintangan elektrik dalam eksplorasi air bawah tanah yang telah dijalankan dikawasan Bukit Jalil-Serdang, di Negeri Selangor Darul Ehsan, Malaysia. Tinjauan pengimejan kerintangan elektrik telah dijalankan untuk mengenalpasti lokasi dan memetakan sumber air bawah tanah serta menganggarkan jumlah kandungan air yang terdapat didalam sumber tersebut. Konfigurasi elektrod Wenner telah digunakan dalam kajian ini. Kerja lapangan di sepanjang tiga belas profil telah dikendalikan. Keratan rentas bermodulasikan warna bagi kerintangan bahan melawan kedalaman telah diplot untuk semua profil yang menghasilkan imej bagi struktur dibawah tanah. Kajian dimakmal juga telah dijalankan bersama-sama kajian dilapangan.

Kerintangan sampel batuan dan tanah telah diukur. Jumlah kandungan liang rongga bagi sampel-sampel batuan dan tanah ini juga telah dikira. Daripada nilai kerintangan ini, faktor formasi telah diperolehi. Satu hubungan antara jumlah kandungan liang rongga dan faktor formasi telah diperolehi. Kaitan faktor formasi-kandungan liang rongga ini telah diaplikasikan keatas data-data kerintangan elektrik yang diperolehi dari lapangan. Penggunaan kaitan ini telah menghasilkan nilai keronggaan bagi formasi-formasi batuan dikawasan kajian.

Nilai-nilai jumlah kandungan liang rongga telah dikontur dan diplotkan. Kedalaman batuan desar di bawah tiap-tiap geris rentasan telah diperolehi. Satu gambaran 2-dimensi dan 3-dimensi topografi permukaan batuan dasar telah disediakan dengan menggunakan perisian komersial. Penggunaan perisian ini juga telah membolehkan pengiraan jumlah kandungan air tanah yang terdapat di kawasan kajian.

Keputusan menunjukkan lapisan pada akuifer memiliki kerintangan di antara 20 Ω.m dan 150 Ω.m dan berada pada kedalaman yang di antara 5 hingga 20 m. Lapisan ini mempunyai jumlah kandungan liang rongga di antara 18% dan 35%. Keputusan daripada profil kerintangan elektrik menunjukkan, akuifer yang dikaji meliputi kawasan permukaan seluas 15,977,900 m^2 dan memiliki purata

kedalaman 13 m dari permukaan dengan isipadu bersih 204,610,000 m^3. Purata jumlah liang rongga bagi akuifer ialah 30%. Oleh itu kapasiti penggunaan 61,383,000 ± 6,752,130m^3 boleh diperolehi.

ACKNOWLEDGMENTS

Firstly Praise be to Allah for giving me the strength and patience to complete this work and Peace be upon his final Prophet and Messenger Mohammed. My full thanks to associate professor, Dr. Shaharin bin Ibrahim, chairman of my supervisory committee, for his useful discussions, invaluable suggestions, unlimited assistance, beneficial advice and continuous encouragement through out this work. I have the highest regard for his professional courtesy and the profound humility of his character.

Similar thanks must go to members of my supervisory committee, associate professor Dr. Wan Nor Azmin bin Sulaiman and associate professor, Dr. Mohd Kamil bin Yusoff, for taking interest in and offering helpful suggestions and guidance.

I would like to thank members and staff in the department of physics who have always willing to offer assistance, in particular, Mr. Mohd Shah Ibrahim, Mr. Roslim Mohd, Mr. Nordin Abdul Kadir and Mr. Razak Harun. I would like to take this opportunity to express my thanks to my friends who have helped me in this work: Mr. Ugantharan Maruthaveeran, Mr. Abdelatif Mukhtar, Mr. Elrashied Imam Elkhidir and Mr. Elsadig Eljack.

Higher Education Ministry (Sudan) and Malaysian Technical Corporation program (MTCP) which is highly appreciated and gratefully acknowledged provided financial support. May Allah reward my supervisor and committee for their dedication and service to humankind.

I certify that an Examination Committee met on January 27, 2000, to conduct the final examination of Hago Ali Hago Ali, on his Master of Science thesis entitled "Application of Electrical Resistivity Method in Quantitative Assessment of Groundwater Reserve of Unconfined Aquifer" in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulation 1981. The Committee recommends that the candidate be awarded the relevant degree. Members of the Examination Committee are as follows:

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This thesis was submitted to the Senate of Universiti Putra Malaysia and was accepted as fulfillment of the requirements for the degree of Master of Science.

KAMIS AWANG, Ph.D.
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Date: 11 MAY 2000

DECLARATION

I hereby declare that the thesis is based on my original work except for quotations and citations, which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at UPM or other institutions.

Hago Ali Hago Ali

Date: 24/2/2000

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INTRODUCTION

Groundwater is a major source of clean drinking water all over the world. It has been an important resource especially in the dry part of the world. Groundwater has been used in Malaysia for many decades (Ang, 1994).

Increased demands for water have stimulated development of underground water resources. As a result, techniques for investigating the occurrence and movement of groundwater have been improved, better equipment for extracting has been developed, concepts for resource management have been established, and the research has contributed to a better understanding of the subject.

Since geophysical exploration is the scientific measurement of physical properties of the earth crust for investigation of mineral deposits or geologic structure, the present project conducted mainly to apply electrical resistivity method in groundwater exploration, in particular to estimate the groundwater reserve within the unconfined aquifer.

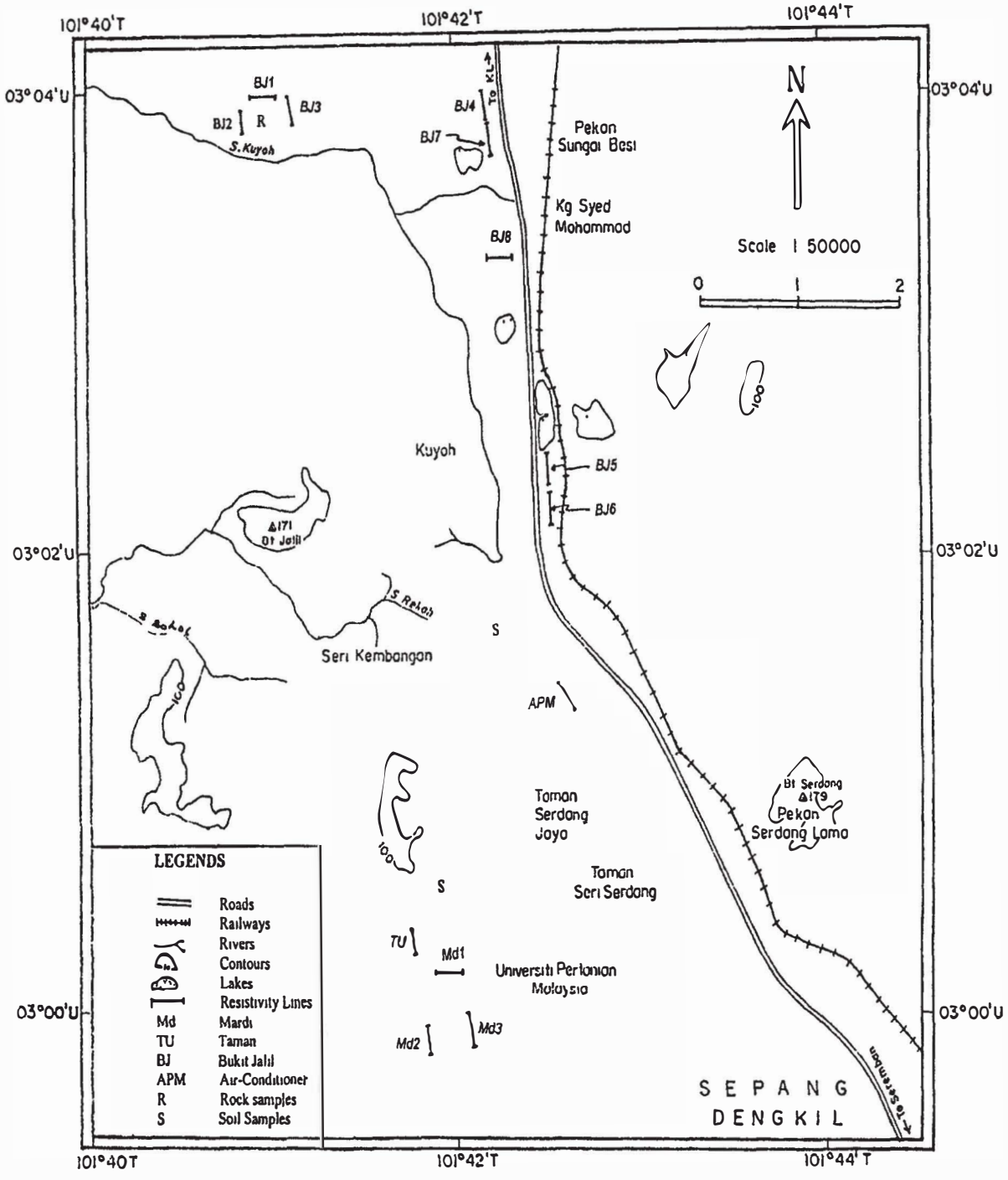

Figure 1: Map Showing the Locations of the Study Area, Samples and Electrical Resistivity Imaging Lines

PREVIOUS WORK IN THE STUDY AREA

The geological survey of Malaysia first started hydrogeological investigations in Peninsular Malaysia in 1903. The only previous published account of the geology of the whole of the present area was entitled "Account of the geology and mining industries of south Selangor and Negeri Sembilan" (Willbourn 1922). A geological map accompanies this publication on a scale of 1 inch to 4 miles.

Ahmed and Othman (1992, 1997), using DC resistivity and other methods to provide sharp lateral resistivity variations by electrical profiling carried out two geophysical investigations. The resistivity profiling was carried out at Sungai Besi Toll plaza along the Kuala Lumpur-Seremban Highway using Wenner array with 10m-electrode spacing. They found that in the first line, the southern part has low resistivity value due to higher water and higher clay content. In the second line the resistivity profiling results show localized anomalies occurring at several parts of the line which is most probably due to the presence of week zones in the sediment layer.

OBJECTIVES OF THE PRESENT STUDY

The primary objective of the present study is to apply electrical resistivity method in the quantitative assessment of groundwater reserve. From the combination of the resistivity techniques used in the field, processing and